185 3

VINEGARS and CATSUP

INTERPRETATION OF STANDARDS, ANALYSES, ETC

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PREFACE

The following matter deals with the Federal standards for various vinegars and a proposed standard for tomato catsup. It is an attempt to interpret the necessarily scientific terms and requirements of said standards and acquaint the manufacturing and wholesale trade with a little of the science of what is, or should be, a quite scientific industry. All chemical data of vital consequence was determined by the official testing methods called for in the Federal food law regulations and upon which the Federal food standards are based.

R. O. Brooks.

PART I—VINEGARS

THE use of vinegar for condimental purposes, particularly wine vinegar, is very ancient, probably being contemporaneous with the utilization of wine itself. Practically any fruit juice capable of alcoholic fermentation can be converted into a vinegar by a subsequent acetous fermentation, which is also true of weak sugar syrups and honey solution. Moreover, of course, a weak alcoholic spirit distilled from a suitable fermented "mash" can be likewise subjected to an acetous fermentation, furnishing the so-called "distilled" or "spirit vinegar."

Vinegar is essentially a dilute solution of acetic acid, but it must be remembered that it is the product of a definite fermentation, containing appreciable quantities of certain solid and liquid substances derived from the material thus fermented, and that a solution of acetic acid (as purchased in the chemical market) reduced to proper strength can only be considered as an imitation spirit vinegar, at the best. And as an imitation of a good spirit vinegar it would be a very poor makeshift.

The constituents other than acetic acid which are present, as well as the characteristic flavor, etc., of a true vinegar depend, of course, upon the nature of the material which has been fermented into vinegar. The four principal vinegars in use at present are: Wine vinegar, resulting from the alcoholic and subsequent acetous fermentations of grape juice; cider vinegar from properly fermented pure apple cider; malt

vinegar from the alcoholic and subsequent acetous fermentation of an undistilled infusion of barley malt or cereals whose starch has been converted by malt; and spirit vinegar, as mentioned above. In addition there is more or less manufacture and sale of a sugar or syrup vinegar made from the alcoholic and subsequent acetous fermentations of solutions of syrup, molasses, etc.; glucose vinegar from similarly fermented glucose solutions; honey vinegar from fermented honey solutions; and special fruit vinegars, for instance, a vinegar is now being made from the juice of prunes.

In some countries a certain vinegar is often so extensively used, or was so exclusively used originally, as to restrict the simple term, vinegar, to that particular variety, as, for example, malt vinegar in England, or wine vinegar in Continental Europe. In the United States the only vinegar known for years was cider vinegar, and among food inspection authorities it has always been customary to hold that when the consumer simply asks for "vinegar," cider vinegar is called for and should be furnished by the dealer. Thus the Federal food standards (Circular 19, Office of Secretary, U. S. Department of Agriculture) restricts the single term "vinegar" to indicate cider vinegar.

The artificial coloring of vinegar is prohibited by many State food laws, while a certain few more liberal-minded state food inspection departments have allowed the use of a harmless color (caramel is customarily used) in vinegars having a distinct color naturally, provided the fact be stated on the label. It can be readily seen that the coloring of a naturally colorless vinegar, as, for instance, spirit vinegar or

glucose vinegar, is for fraudulent purposes only.

Vinegars are subject to more or less deterioration, dependent upon age, purity and method of storing; it being possible for certain vinegars, in time, not only to lose all their acetic acid, but to become actually alkaline in reaction. This deterioration is due almost wholly to a destructive fermentation, caused evidently by bacteria of the *Bacterium xylinum* type, as a cellulose containing "mother" is formed. Bertrand (*Comptes Rendus,* 122, 900) states that the well known small vinegar flies (*Drosophila cellaris*) which frequent places where fruit juices are fermenting, introduce the *Bacterium xylinum.* Pasteur claimed that the acetic acid forming bacteria themselves (*Mycoderma aceti* and *Bacterium Pasteurianum* principally) after converting the alcohol into acetic acid, consume the latter, forming carbon dioxid and water.

Vinegars also frequently are found to be increased in acetic acid strength, due to their having been put upon the market before all the alcohol of the fermented juice or infusion has been fermented into acetic acid. As is well known, the alcoholic fermentation itself is caused by various species of yeast (*Eumycetae*) through the agency of the ferment or enzyme, recently isolated and known as zymase.

The constituents of a vinegar other than acetic acid, which are present, vary, as said before, according to the nature of the fermented juice or infusion or distilled spirit from which the vinegar has been made. In distilled or spirit vinegar there is naturally very little solid matter, but in other vinegars, noticeably malt, cider and wine vinegars, the proportion of solids is not only appreciable but sometimes relatively

high. These solid constituents may furnish some of the characteristic flavor of a vinegar, but the principal cause of flavor and odor (aside from the usual acetic odor) are certain fluid constituents of an ester nature. In a well-aged cider vinegar the odor of ethyl acetate is often very strong, in fact the writer knows of a case where the "vinegar stock," or cider which had undergone fermentation, contained little or no alcohol, no acetic acid, but a considerable quantity of the esters, particularly ethyl acetate.

The greater proportion of all the vinegar sold in this country is made by the so-called "generator" or "quick process," but there is no denying that a properly conducted cask fermentation extending over a period of a year or so furnishes a superior product, particularly as concerns flavor, odor, etc. The use of selected yeast cultures for converting the original fruit juice into an alcoholic liquid, as is the custom in Europe, would no doubt offset some of the disadvantages of the "generator" process and would yield a magnificent product by a "cask fermentation."

In succeeding papers we will take up in turn each of the various vinegars with especial reference to their chemical make-up, etc., as called for in the Federal food standards. Later a number of other food products of a condimental nature, other than spices, will be considered.

PART II—CIDER VINEGAR

AS pointed out in the introductory article of this series, the single term "vinegar" in America meant originally and exclusively cider vinegar, and in food inspection circles it has always been held that when a customer asks for simply "vinegar," cider vinegar must be served by the dealer, or, at least, any substitution of another kind of vinegar made plain to the purchaser. Thus in the Federal food standards (Circular 19, Office of Secretary, U. S. Dept. of Agriculture), "vinegar" is considered as synonymous with "cider vinegar" or "apple vinegar," the "product made by the alcoholic and subsequent acetous fermentations of the juice of apples, is levorotatory and contains not less than 4 grams of acetic acid, not less than 1.6 grams of apple solids, of which not more than 50 per cent. are reducing sugars, and not less than 0.25 gram of apple ash in 100 cubic centimeters (20°C.); and the water soluble ash from 100 cubic centimeters of the vinegar contains not less than 10 milligrams of phosphoric acid (P_2O_5) and requires not less than 30 cubic centimeters of deci-normal acid to neutralize its alkalinity."

The usual State standard in the past has been a very simple requirement of at least a certain acetic acid strength (usually 4 or 4.5 per cent.) and at least a certain proportion of solid residue (varying from 1.5 to 2.0 per cent.), with very

rarely a limit (0.25 per cent.) for ash (residue left upon properly incinerating the total solids) and a frequent prohibition of any artificial color. Now in the manufacture of cider vinegar, some very shrewd sophistications were sometimes intentionally, but more often unwittingly, practiced, and the State standard of the past was utterly useless in detecting or preventing such, as acidity could be easily manipulated by means of commercial acetic acid and solids and ash could be furnished by almost any non-volatile substance.

The Federal standard (in which grams per 100 cubic centimeters correspond very closely to per cents.) is an attempt to fix limits with which only a straight apple (juice) vinegar can comply, and although it is faulty in certain respects, principally in the liberality of the reducing sugar limit, yet only an occasional shrewdly sophisticated sample will pass muster; and such crude adulterations as were possible under State standards would never pass. This standard has now been adopted in full or in part by a number of State inspection departments and in time will be quite generally adopted in State food inspection circles.

The first part of the Federal standard for cider or apple vinegar specifies a product made by certain fermentations of "the juice of apples," and although many vinegar makers buy an already alcoholic fermented "vinegar stock," yet others carry through the process from the culture of the apple tree up to the finished product and, as a proper understanding of the Federal cider vinegar standard necessitates studying back as far as the apple juice, we will begin with the apple itself.

The apple (*Pyrus malus*) belongs to the Pome class of fruits and many different varieties exist. In France, Germany and England the culture of special varieties peculiarly adapted for the manufacture of cider is quite ancient and the utilization of the juice of these varieties in connection with pure cultures of yeasts and a general scientific control of the process has resulted in a beverage industry rivaling the wine industry itself.

Alwood (Bulletin 71, Bureau of Chemistry, U. S. Dept. of Agriculture) has carefully studied the cider industry in England and continental Europe, and his observations lead us to believe that although our grape juice and wine industry is fairly well developed, we have not as yet made a beginning in apple beverage manufacture (aside from a couple of brands of mediocre-quality, high-priced apple juice), in spite of the fact that the United States is one of the greatest apple-raising countries. This is due principally to three causes: First, but not so very important, is the absence of special cider apple orchards; second, the utilization of only the poorer apples for cider and vinegar manufacture; and third, the utter lack of scientific methods, such as the use of pure yeast cultures, controlled fermentations, etc.

In France in the year 1900 the manufacture of commercial high-grade cider exceeded 647,000,000 gallons, while the value of the English output annually (more than 100,000,000 gallons) is estimated at $15,000,000. Our apple crop is capable of great increase, and the manufacture of high-grade unfermented and fermented apple juice and cider vinegar might become a great and lucrative industry, particularly

when our Federal food law is enforced to prevent fraud rather than exploit imaginary hygienic controversies.

The chemical composition of the apple, while not so important for our purposes as the composition of the apple juice or must, is of interest, and the following average analysis by Browne, who analyzed all the important American varieties, is the most complete yet made:

	Per Cent.
Water	84.0
Reducing sugars (d—glucose and levulose	8.0
Saccharose (ordinary sugar)	4.0
Starch (absent in ripe apples)	0.1
Cellulose	0.9
Lignin	0.4
Pentosans	0.5
Pectins	0.4
Malic acid (free)	0.6
Malic acid (combined)	0.2
Oil (fatty)	0.3
Protein (N x 6.25)	0.1
Ash (mineral matter)	0.3
Undetermined (tannin, etc.)	0.2

The ash of the apple is made up principally of potassium carbonate (about 68 per cent.) and potassium and magnesium phosphates (about 22 per cent.), the significance of which will become plainer when we consider the total and soluble ash requirements of the apple juice, cider and cider vinegar standards.

It is beyond the scope of this article to go deeply into the chemistry of the various chemical substances found in the apple. Briefly, the reducing sugars are a group of sugars capable of reducing an alkaline copper salt solution to

cuprous oxid, and they are usually estimated by means of this reaction. The two reducing sugars present in the apple are d-glucose,* $C_6H_{12}O_6$, identical with grape sugar; and levulose, having the same formula and sometimes known as fruit sugar. The prefix d- refers to the optical effect of a solution of the sugar upon the plane of polarized light and is an abbreviation of *dextro,* meaning that the plane of polarized light is rotated to the right. Levulose, however, is levorotatory (rotating the plane of polarized light to the left), and as the levorotatory effect of levulose is greater than the dextrorotatory effect of the same quantity of d-glucose, the mixture of the two sugars in equal proportions (known as "invert sugar") is levorotatory; and in the apple and apple juice where levulose predominates, the reading on the polariscope (an instrument for measuring the rotation of the plane of polarized light) is strongly levorotatory, as we will see.

The saccharose in the apple is identical with sugar from sugar cane, sugar beets, etc. Its formula is $C_{12}H_{22}O_{11}$, in solution it is dextrorotatory, and as saccharose it is not directly fermented by the alcohol-forming enzyme (zymase) of yeast, like levulose and d-glucose are. By means of an enzyme in the yeast, known as invertase, it is soon converted into "invert sugar" (equal parts of levulose and d-glucose), however, and then ferments into alcohol and certain congeneric products.

Starch is a carbohydrate complex, insoluble in water, and having the formula $(C_6H_{10}O_5)n$, It exists in the green apple in considerable quantity (about 4 per cent.) as microscopic

*Formerly called dextrose.

globular granules about nine microns in diameter, but as the apple ripens it disappears, being in part converted by enzymes in the apple into sugar. The juice from green apples is slimy or turbid (due to suspended starch mainly), and on account of this and the deficiency in sugars, as will be illustrated by analyses later, is not at all adapted for cider or cider vinegar making.

Cellulose has the same general formula as starch, but is even more complex, is insoluble even when boiled with dilute acid or alkali, and with lignin and the pentosans (hemicelluloses), both of which are substances closely related to starch, constitute the material which make up the cell walls of the apple, the cells being the minute receptacles containing the juice. The analytical item in food analysis known as "crude fiber" is mainly cellulose and the dried marc, or completely leached apple pomace (constituting about 2 per cent. of the apple) is about one-half cellulose.

Pectins are soluble gum-like substances, which under certain influences cause apple juice to gelatinize or "set," thus being of great importance in the manufacture of apple jelly. The principal acid of the apple is malic acid [oxy-succinic acid, C_2H_3 (OH) $(COOH)_2$], the greater part being in free form, although a certain proportion is in the form of salts known as malates. Separated out and crystallized it forms a white, deliquescent solid substance of intensely acidulous taste. The sourness of a ripe apple is due entirely to its acid content and not to absence of sugars; frequently sour apples are found to contain more sugars than those tasting sweeter. The proportion of free

malic acid present may range from 0.1 per cent. in the "Sweet Bough" to 1.11 per cent. in the "Red Astrachan" and as high as 2 per cent. in a very green apple.

The fatty oil of an apple is almost entirely a constituent of the seeds and this is true to considerable extent of the nitrogenous matter, which is reported rather vaguely as "protein" or the per cent. of nitrogen multiplied by 6.25. The "undetermined" matter in the preceding analysis includes besides tannin the traces of esters, which furnish the apple odor and characteristic flavor. In the apple amyl valerate is probably the principal ester present, but in fermented juice products (cider and vinegar) other esters develop to give the bouquet, which has much to do with deciding quality.

Tannin, or tannic acid, is a rather interesting and important constituent, being the cause of the puckering effect on mouth membranes of the crab apple, and, what is more interesting, the bitter-sweet taste of the French cider apple. In fact, the expert French cider manufacturer ranks the tannin content of his apple next in importance to the sugar content and insists upon a minnimum of 0.3 per cent. in the apple, and as high as 1 per cent. is tolerated. It assists in clarifying the juice products and tends to retard the alcoholic fermentation to the enhancement of the soundness and keeping quality of the cider. The American and German fruits are decidedly deficient in tannin, but the Germans get around the difficulty by using a certain proportion (one part in twenty) of the juice of the Speierling crab apple (*Pyrus* or *Sorbus domestica*). The use of a similar apple juice rich in tannin or even commercial tannin itself

could easily remedy the tannin deficiency in American cider manufacture.

Unless, however, a sufficient percentage of malic acid is present in the fruit and its juice (which is the case in American apples) the oxidation of the tannin by means of a special oxidizing enzyme (oxidase) may cause the juice to turn nearly black, a point which to a moderate degree might be considered advantageous by the cider vinegar manufacturer, who usually wants a rich brown color in his product. A sweet apple juice with the right proportion of tannin would be a good color-producing combination therefore. The rapid browning of apple flesh after the contents of the apple cells become mixed by cutting or paring is due, of course, to the oxidation of tannin by the enzyme (oxidase), which is prevented in commercial evaporated apples by exposing to the fumes of burning sulphur (sulphurous acid), another innocent practice under the ban of the hygienic controversalists.

Regarding the variations in the proportion of sugars present in apples, some data are of interest as on this item the yield of alcohol and subsequently acetic acid is directly dependent The sugars, particularly the saccharose (cane sugar) increase as the fruit ripens and decrease slightly as it over-ripens. Reckoning the reducing sugars and the saccharose as "total sugar," the proportion present in various kinds of apple varies considerably. Some of the more famous French cider apples contain as high as 26.3 per cent. total sugar, the average for the Bramtot being 19 per cent. and for the Grise Dieppois 20.2 per cent.! The average for the French cider apples as a whole, however, is between

15 and 16 per cent. total sugar, which is only 4 per cent. more than the American apple average, and less than the average for our Golden Russett, which for ten samples was found by Browne to be 16.5 per cent. Crab apples average about 11 per cent. total sugar.

In the next installment of this series we will deal with the composition, etc., of the apple juice and its fermentation into cider, "hard cider," as commonly called in this country. Right here it is interesting to note that a "fruit juice" ("juice of apples" is the wording of the Federal cider vinegar standard, remember) is defined in the proposed supplementary Federal standards as "the clean unfermented liquid products obtained by the *first pressing* of fresh, ripe fruits." The relation of this requirement to the utilization of "second pressings" in vinegar manufacture, we will endeavor to make plain in a way fair to all concerned.

PART III—CIDER VINEGAR (Cont.)

AS said in preceding article, the sugars, particularly the saccharose or common sugar, increase as the apple ripens, the starch of the green apple being largely, if not entirely, converted into saccharose. This indicates the desirability of using only fully ripened fruit in the preparation of an apple juice or must, as the juice from unripe fruit is turbid and slimy (from suspended starch) and the alcoholic strength of the cider and subsequent acid strength of the vinegar is proportional to the amount of sugars present. The saccharose reaches a maximum at just about the same time that the starch in the apple completely disappears. This may be appropriately called the ripening point, although, as we will see, the proportions of various sugars present continue to change for several months during storage, to the enhancement of the cider and vinegar-making value of the apple. The average analysis of the ripe apple given in the preceding article showed an average saccharose content of 4 per cent. Colby at the California Experiment Station reports as high as 7.8 per cent. saccharose, his average, however, being but a little over 4 per cent.

During storage, after ripening, the sac-

charose, which has attained a maximum coincident with the disappearance of starch, gradually decreases, being converted into reducing sugars (directly fermentable), so that at a period from one to four months in common storage and as long as from fourteen to seventeen months in cold storage, the saccharose is found to be 1 per cent. or less and the reducing sugars about 3 to 4 per cent higher, except after cold storage, when the increase in reducing sugars seems to be somewhat less.

Now, as to the proportion of apple juice or must obtainable from apples. The usual French cider industry requirement in this respect is that the apple shall furnish at least 55 per cent. of its own weight of juice. Anyone who has ground up apples on crushing or grating machines and has tried pressing out the juice with the ordinary hand press knows that only about one-half of the juice in the fruit can be obtained. It is practically an impossibility to rupture all the cells of the apple by grinding or to extract all of the juice by pressure. With an 80-ton hydraulic press at the Virginia Experiment Station the best average was 70 per cent. of the weight of the apple recovered as juice. Moreover, as a considerable percentage of the weight of the recovered juice consists of solids in solution, the actual amount of juice left in the pomace is greater than appears from the percentage of weight recovered.

Eight varieties of summer apples finely chopped and thoroughly pressed in a hand press gave an average of 53.2 per cent. juice and 43.3 per cent. pomace, there being an unavoidable loss of 3.5 per cent. For eleven autumn varieties the juice recovered was (by weight) 53.9 per cent.,

pomace 44.0 per cent., loss 2.1 per cent. For nineteen winter varieties the juice recovered was 52.2 per cent., pomace 45.6 per cent., loss 2.2 per cent. Seven crabapples gave 57.3 per cent. juice, 41.4 per cent. pomace and 1.3 per cent. loss. Factory machinery will, of course, better these figures, yet it can be readily seen that a considerable proportion of juice and valuable saccharine matter may be left in the pomace, and if by saturating with cold or warm water and repressing a so-called "second pressing" can be obtained, fairly rich in fermentable sugars, we see no reason why this should not be allowed to be judiciously used in diluting a rich first pressing juice intended for "vinegar stock." Calculated as the percentage of total sugars of the apple remaining in the pomace the average value for the above-mentioned summer apples was 47.1 per cent.; for the autumn apples, 44.7 per cent.; for the winter apples, 41.7 per cent., and for the crabappless, 38.8 per cent. *In other words, nearly half of the total sugars in the apple are lost unless "second pressings" are utilized.*"

The Federal standard for cider vinegar, preliminary to fixing a series of analytical limits, defines that vinegar as the "product made by the alcoholic and subsequent acetous fermentations of the juice of apples." In the supplementary food standards proposed, but not yet proclaimed as official, a "fruit juice" is defined as the "clean, unfermented liquid product obtained by the first pressing of fresh, ripe fruit," corresponding in name to the fruit from which it is obtained. Apple juice, apple must or "sweet cider" is defined and standardized as the "fresh fruit juice obtained from apples, the fruit of

Pyrus malus, has a specific gravity (20° C.) not less than 1.0415 nor greater than 1.069, and contains in one-hundred (100) cubic centimeters (20° C.) not less than six (6) grams and not more than twenty (20) grams of total sugars in terms of reducing sugars, not less than twenty-four (24) centigrams nor more than sixty (60) centigrams of apple ash, which contains not less than fifty (50) per cent. of potassium carbonate." The term "reducing sugars" was explained in the preceding article, and it was also pointed out that the ash of the apple contained on the average about 68 per cent. of potassium carbonate. This potassium carbonate requires a certain amount of an acid solution of standard strength (tenth-normal acid is usually used) to neutralize its alkalinity; hence the final analytical limit given in the complete Federal cider vinegar standard (see preceding article or Circular 19, office of Secretary, U. S. Dept. of Agriculture).

From the above facts it would appear that the utilization of "second pressings" was ruled out, even for vinegar manufacture. As concerns apple juice ("sweet cider") for beverage purposes, the "first pressing" requirement may be desirable, and this probably applies to cider (so-called "hard cider"), the alcoholic fermented apple beverage also. For the manufacture of apple vinegar (so-called "cider vinegar"), particularly for table purposes, where a low acid strength (4 to 4.5 per cent.) is preferable, provision in the standards should be made for the utilization of "second pressings" (defined and standardized if necessary) and the Federal apple vinegar standard modified to accommodate such a practice.

Some analyses of pomace from different groups of apple varieties follow:

Apples.	Moisture.	Reducing sugars.	Saccharose.*	Total sugars†	Tannin.	Ash.
	Per cent.					
Summer (10):						
Maximum	85.10	6.69	4.78	10.50	0.01	0.44
Minimum	80.25	4.33	1.70	7.00	....	0.27
Autumn (13):						
Maximum	85.10	6.85	3.85	10.90	0.09	0.61
Minimum	70.25	5.54	1.70	7.78	0.01	0.30
Winter (19):						
Maximum	84.65	7.09	4.43	11.46	0.17	0.43
Minimum	78.65	5.11	1.08	8.09	0.01	0.23
Crab (7):						
Maximum	90.00	10.15	4.43	11.76	0.19	0.62
Minimum	38.05	5.06	1.30	10.09	0:06	0.31

*Cane sugar. †As reducing sugars.

NOTE.—Figures in parenthesis indicate number of varieties.

We have gone into detail somewhat as concerns the composition of apple pomace, because it is upon this data that our contention rests, viz., that in the manufacture of apple vinegar at least, the use of a properly standardized "second pressing" should be provided for in the Federal food standards. The above data is taken from a bulletin (No. 88) of the Bureau of Chemistry, U. S. Dept. of Agriculture, which means that at least one member of the Food Standards Commission was aware of the facts of the case. The total sugar (as fermentable reducing sugars) average as follows for each of the above classes of apples, viz., summer apples, 8.68 per cent.; autumn apples, 9.12 per cent.; winter apples, 9.34 per cent., and crabapples, 10.25 per cent. Comparing these last figures with the rather liberal average analysis of the whole apple, as given in the preceding article, we see an average reduction of but about 2.5 per cent. in fermentable sugar value.

As to the composition of apple juice or must (see above standard) hundreds of analyses are

available, and in one hundred analyses representing nearly a hundred varieties of American apples (see below), the writer was able to find but one sample (a rich Baldwin juice) that exceeded the specific gravity limit of 1.069, with none below the minimum in gravity and sugar content and ash and only seven samples showing 24 centigrams of ash, which is the minimum called for in the apple juice standard.

The maximum and minimum values obtained in the one hundred analyses of pure apple juice are as follows:

	Minimum.	Maximum.	Average.
Specific gravity	1.042	1.072	1.055
Grams, per 100 c.c.:			
Total solids	10.16	18.81	13.61
Reducing sugars	4.67	11.63	7.20
Saccharose	0.48	7.05	3.44
Total sugars	6.74	15.39	10.79
Tannin.	0.002	0.214	0.06
Ash	0.24	0.87	0.30

In addition to the above, some data on the acidity (as per cent. of malic acid) of apple juices is of interest. The range in the above one hundred analyses is from 0.073 per cent. in the Sweet Bough apple juice to 1.15 per cent. in the Red Astrachan apple juice. An average would be about 0.55 per cent. malic acid. The maximum and average for tannin are both of interest, the latter because it demonstrates the tannin deficiency in American apple juices as compared with the French cider-making requirement of at least 0.2 per cent. tannin and the former, as it shows that certain crabapples, in this case the Red Siberian crabapple, are up to or above the French cider apple juice tannin requirement. As to the exact make-up of the reducing sugars present in apple juice we have not much data. A sample used in some fermentation experiments by Browne showed 7.4

per cent. levulose to 2.9 per cent. d-glucose. During the alcoholic fermentation the latter disappeared soon after the saccharose (cane sugar) present disappeared, but the levulose persisted in small proportion throughout the alcoholic and acetic fermentations, which explains the slight levo-rotatory polariscope reading required in the Federal standard for cider vinegar, and always noticeable in such if care be exercised in the test. In fresh apple juice Browne reports for eleven varieties of summer and winter apples a range of from —19.24° to —49.00° Ventzke using a 400-millimeter tube, the average being —35.9°.

The following analysis of a particularly rich juice from a green Baldwin apple is of interest. Only very rarely would the juice from a green apple approximate these figures, which shows, aside from the undesirable turbidity, etc., the unfitness of unripe apples for cider and vinegar making:

Appearance	Slimy and turbid
Starch (in the apple)	5.14%
Specific gravity (of juice)	1.0474
Total solids (in the juice)	11.36%
Reducing sugars	6.64
Saccharose	1.56
Total sugars (after inversion)	8.28
Malic acid	1.18
Alcohol yield (sugars x 0.46)	3.81
Acetic acid yield (alcohol x 1.20)	4.57

The above alcohol and acetic acid yields are less than theoretical, but in actual practice the vinegar obtained from even such a rich juice as the above would be in all probability below standard.

As concerns the analytical values on "second pressings" the writer has been able to find but one analysis (by Browne). Much depends, of course, upon how much water is used for wet-

ting the pomace and how thoroughly the same is macerated with the water before repressing:

Specific gravity	1.0876
Total solids	9.14%
Reducing sugars	6.87
Saccharose	1.49
Ash (mineral matter)	0.20

Such a juice would furnish a 4 per cent., probably a 4.5 per cent., acetic acid vinegar, but in total solids and ash the vinegar would, of course, be below standard. However, people buy apple or cider vinegar for the acid taste and apple flavor and bouquet and not for the 2 or 3 per cent. of mineral matter, gums, etc., that may be incidentally present. The utilization of "second pressings" (standardized preferably) should by all means be allowed in conjunction with straight apple juice in vinegar manufacture. Much of this "second pressing" juice is now used in making cider jelly or so-called "boiled cider," which in turn is extensively used to fraudulently sophisticate true apple vinegar. Diluted acetic acid, or spirit vinegar, reinforced with the jelly and possibly mixed with some true vinegar to furnish flavor, was for a long time considered a very shrewd adulteration. Even yet the very liberal reducing sugar limit in the Federal apple vinegar standard renders the practice fairly safe if judiciously regulated. An analysis of cider jelly by Browne follows:

	Per cent.
Moisture	44.58
Reducing sugars	49.50
Saccharose	2.18
Malic acid	3.61
Pectin	1.60
Ash (mineral matter)	1.39

In our next article we will take up the details and product of the first or alcoholic fermentation. Later the acetic fermentation and final products will be considered, with special reference to the Federal standard requirements.

PART IV—CIDER VINEGAR (Cont.)

IN the two preceding articles of this series we have considered the raw materials of the cider vinegar industry, viz., apples and apple juice. In this instalment we will consider briefly the first of the actual fermentation processes, i. e., the alcoholic fermentation, or the conversion of apple juice into cider, the so-called "hard cider" of this country.

The manufacture of cider as a beverage of quality is considered by experts to be more difficult and to necessitate more careful control than the manufacture of most grades of wine. As intimated in the introductory note to this series of articles, only a very small proportion of what is sold as "cider" in this country has a claim to the name and a still smaller proportion, in fact what might be called a negligible quantity only, can be considered as a beverage of quality. In England and continental Europe and in France particularly, the manufacture of high grade cider constitutes an important industry, rivaling the wine industry. In 1898 over one million citizens of France were entered upon Government reports as cider manufacturers and from the apple crop of 1900 more than 647,000,000 gallons of commercial, good quality cider were produced, not taking into account that produced for home consumption.

We are not going so far as to say that the manufacture of a high grade cider is a prerequisite to the production of good apple vinegar. Compared with much of the dilute acid

sold for condimental purposes in this country, a very poor apple vinegar is a superior article and commands a higher price. Yet it has been a matter of frequent mention in technical literature that the bulk of the apple vinegar sold in this country was just about on a par in quality with the cider sold. The causes, such as the utilization of rotten, unripe and generally inferior fruit and careless, unscientific, aye slovenly methods of manufacture have been dwelt upon in said literature so often that to repeat them here is impracticable.

A high grade cider may not be a prerequisite to the production of a fairly good grade vinegar, but as the acetic fermentation as now conducted in rapidly acting generators, involves little more than the conversion of alcohol into acid, it will be admitted that the better the alcoholic fermented product (cider or "vinegar stock") the better the condimental product (vinegar) will be. The vinegar obtained by the old-fashioned cask method of fermentation was a superior product as regards flavor and bouquet and to counteract the inferiority of the commercially necessary generator process, we must look more to the nature and quality of the apple juice, both fresh and alcoholically fermented A cider, carefully made with well developed flavor and bouquet and passed through a clean, well controlled generator may yield even a better product than the vinegar made by the cask fermentation.

As to the manufacture of ciders for beverage purposes, it is not the province of this series of articles to deal with, and as the technique and related details of the various methods of procedure in different countries would fill a

good sized volume, it is impracticable to go into the manufacturing details of cider production here at all. To the would-be progressive cider and apple vinegar manufacturer, however, the writer can recommend several governmental bulletins, to be had for the asking or at the most a nominal fee of a few cents, which portray in a truly fascinating way what has been accomplished in France, Germany and England in the manufacture of cider, the methods in vogue (complete details) in each country and the results of experimental work in this country on scientifically controlled fermentations, utilizing the characteristically inferior apple juices available, or rather allotted to cider and vinegar manufacture in America. These are Bulletins 71 and 88 of the Bureau of Chemistry, U. S. Dept. of Agriculture, entitled "A Study of Cider-Making in France, Germany and England," and "The Composition of Cider as Determined by Dominant Fermentation With Pure Yeasts." The sole author of the first and principal author of the second is Dr. William B. Alwood of Charlottesville, Va., Enological Chemist of the Bureau of Chemistry.

The first or alcoholic fermentation of apple juice is due, as is well known, to the activities of the yeast cell, and to quote Bulletin 71, "the quality of the resultant product depends upon whether desirable or undesirable organisms gain the mastery in the must (or juice) during initial fermentation. In order to insure the ascendancy of the true yeasts in the early stages, and thus give them the control of the entire process of fermentation, there has recently been developed the practice of sowing the must with pure cultures of yeast. Very often special races

of yeasts are used to secure certain desired qualities of bouquet, etc., in the finished product. In Germany practically all the important factories employ these pure cultures." Various fungi will convert sugar into alcohol, but the yeasts, *Saccharomyces cerevisae,* are the true alcoholic fermentation organisms. False yeasts, such as the Apiculatus and other "wild" forms, are frequently the cause of undesirable fermentation results. In practical factory work it has not been found advisable to first sterilize or even pasteurize the juice as the finer natural flavors, due to esters, etc., in the juice are injured by attempts at sterilization. If one sows a sufficient amount of a fresh culture of a strong yeast into the freshly expressed juice, a controlling or dominant fermentation is easily secured and the time of the alcoholic fermentation reduced one-half.

The French method of racking off after the quieting down of the first or violent fermentation is preferred by Alwood to the German method of completely fermenting out the sugars before racking off. The latter method gives a better standardized product, but one lacking in the quality of the French products. The preferable temperature for the yeast fermentation is between 55 degrees and 65 degrees Fahrenheit, but when between 65 degrees and 75 degrees Fahrenheit is more rapid.

The direct agents in the process are two enzymes produced by the growing yeast plants and known as invertase and zymase. The former converts any saccharose into alcoholic fermentable sugars (invert sugar or reducing sugars) while the zymase is the alcohol and carbonic acid forming enzyme. Various second-

ary reactions also occur whereby small quantities of glycerin, succinic acid and certain aromatic products of flavoring value are formed. About one one-hundredth of the total amount of fermentable sugars present is utilized by the yeast cells for building up cell tissue. Certain nitrogenous substances in the juice are also important as nutriment for the yeast plant. In the German fermentation industries, preparations of zymase are being used in place of yeast cultures.

The theoretical reaction of alcoholic fermentation is chemically expressed as follows:

$$C_6 H_{12} O_6 = 2\ C_2 H_5 OH + 2\ CO_2$$

or one molecule of reducing sugar yields two molecules of alcohol and two molecules of carbonic acid (carbon dioxid). According to this 100 parts of the sugar should yield 51.11 parts alcohol, 48.89 parts of carbon dioxid being given off. As said above, however, some of the sugar is utilized as food by the yeast and according to Pasteur, from 100 parts of reducing sugar can be obtained, but 48.5 parts of alcohol and 46.6 parts carbon dioxid, about 3.3 parts of glycerin and 0.6 part of succinic acid being also formed. Kulisch* reports from 0.38 gram to 0.59 gram per 100 c.c. of glycerin in ciders, the ratio of glycerin to alcohol being approximately 1 to 10.

In actual practice the proportion of alcohol obtained is about 46 parts from 100 parts of fermentable reducing sugar. During the alcoholic fermentation of apple juice into cider, the acetic fermentation, due to certain bacteria acting on the alcohol, usually gets slightly started.

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*Landwirth, Jahrbücher, 1890, 20 p. 100.

Alcoholic Fermentation.

Date.	Specific gravity.	Per cent. Total solids.	Saccharose.	d-glucose.	Levulose.	Total sugar.	Alcohol.	Acetic acid.	Malic acid.	Ash.	Levo-rotation (400 mm. tube.)
Nov. 16	1.0577	13.75	2.93	2.90	7.38	18.36	0.43	0.04	0.43	0.26	—44.18° V.
Nov. 30	1.0462	12.25	1.20	2.86	7.29	11.43	1.67	0.05	0.43	0.24	—53.78
Dec. 16	1.0331	9.48	0.50	2.06	6.28	8.87	3.05	0.06	0.43	0.24	—50.45
Jan. 5	1.0133	5.92	0.09	1.21	2.88	4.19	5.32	0.08	0.40	0.24	—29.60
Jan. 19	1.0067	4.53	0.01	0.44	2.02	2.47	6.03	0.09	0.38	0.24	—18.80
Feb. 16	1,0013	2.89	0.00	0.21	1.17	1.38	6.70	0.11	0.30	0.25	—11.60
Mar. 9	0.9982	2.24	....	0.07	0.54	0.61	6.92	0.11	0.23	0.25	— 5.30
April 3	0.9968	2.10	....	0.00	0.30	0.30	6.93	0.17	0.21	0.25	— 3.40
May 4	0.9969	1.94	....	....	0.24	0.24	7.00	0.27	0.21	0.26	— 2.30
July 27	0.9959	1.80	....	....	0.11	0.11	6.86	0.52	0.20	0.26	— 1.50

More than 0.5 per cent. of acetic acid will retard the alcoholic fermentation considerably and Lafar has shown that out of 15 different varieties of yeast only three were able to cause fermentation, when the acetic acid exceeded 1 per cent. This shows the folly of attempting to hasten the manufacture of vinegar by mixing fresh apple juice with vinegar, a practice not unheard of. The slight proportion of acetic acid formed during the alcoholic fermentation of apple juice probably accounts for the small amount of the reducing sugar, levulose, which escapes conversion into alcohol and, remaining in the finished products, gives the characteristic levorotatory polariscopic reading. The preceding synopsis of the alcoholic fermentation of apple juice as determined by Browne shows the acetic acid to have reached the alcoholic fermentation restraining limit before all the levulose had fermented:

As said previously, the saccharose (ordinary sugar) is first to disappear. The d-glucose (grape sugar) soon follows suit, but, as described above, the levulose persists in small proportion to the end of the acetic fermentation, which we will continue with later. The pectin of the apple juice disappears almost completely during the above outlined fermentation, due possibly to sedimentation. During the last half of the process the esters (formerly called ethers) begin to manifest themselves and in the above instance at the time of the highest alcoholic content the ester number was equivalent to practically 0.1 per cent. ethyl acetate.

One of the most interesting series of changes is that of the malic acid, the characteristic natural acid of the apple. At the end of the above

alcoholic fermentation it had decreased more than 50 per cent. and during the acetic fermentation we will see that it practically disappears, a properly fermented and aged cider vinegar containing none, a fact contrary to the general idea prevalent among cider vinegar manufacturers.

This phenomenon is due to the activity of certain bacteria, especially *Micrococus malolacticus,* which convert malic acid into lactic acid and certain volatile acids. Sterilization prevents it and a low fermentation temperataure tends to retard it. The well-known test with lead acetate solution, given by genuine cider vinegar and thought to be due to malic acid, is really due to other extractive matters of the apple.

The proposed Federal standard for alcoholic fermented apple juice, or cider, defines it as "the product made by the normal alcoholic fermentation of apple juice, and the usual cellar treatment, and contains not more than seven (7) per cent. by volume of alcohol and in one-hundred (100) cubic centimeters (20°C.), of the cider, not less than two (2) grams nor more than twelve (12) grams of solids, not more than eight (8) grams of sugars, in terms of reducing sugars, and not less than twenty (20) nor more than forty (40) centigrams of cider ash.

This standard is absurd for "dry" ciders in several particulars, as will be evident from the subjoined analytical data representing maximum and minimum values reported in the Bureau of Chemistry bulletins on ciders of known normality and purity. The maximum limits for total solids and sugars tolerate the addition of much sugar for fraudulent purposes, while the minimum limit for total solids would rule out many high

grade ciders of known purity. The following data represents about 125 pure ciders:

	Minimum.	Maximum.	Average.
Specific gravity	0.9959	1,0398	1.0086
Alcohol (% by volume)..	1.60*	7.83	5.19
(Grams per 100 c.c.)			
Total solids	1.48	10.81*	3.72
Sugar (as reducing).....	0.02	7.46*	1.69
Acetic acid	0.01	1.96	0.23
Malic acid	0.13	0.55	0.29
Ash (mineral matter).....	0.18	0.39	0.27
Levo-rotation.†	—0.18°	—5.28°	—2.34°

*Characteristic of so-called "small" cider, *i.e.*, underfermented.

†400 mm. tube, degrees Ventzke.

The above averages for total solids and sugars are rather high, for fully fermented ciders particularly, due to the inclusion of data on underfermented products. If the term cider is to be interpreted as "dry" cider ("hard cider") and by "normal fermentation" is understood a complete fermentation, it would appear that the proposed Federal standard for cider needs considerable revision. For conversion into cider vinegar a completely fermented product is desirable, of course.

PART V—CIDER VINEGAR (Concluded)

IN previous instalments of this series of articles we have carried through the process of obtaining apple or "cider" vinegar, from a consideration of the apple itself to the product, known as cider ("hard cider"), resulting from the normal alcoholic fermentation of apple juice. By a "normal alcoholic fermentation" should be understood a complete fermentation of the juice into a so-called "dry" product containing the minimum of unfermented sugars. In various ways, however, such a complete fermentation is purposely or unintentionally prevented and the proposed Federal standard for cider is so set, as pointed out in preceding article as to accommodate a so-called "small," or underfermented, cider containing very little alcohol and a large percentage of sugars. Thus, a contradiction exists in the standard for cider, which, however, is not taken into consideration in the standard for cider vinegar. *In other words, the analytical limits in the cider standard allow a product which, when made into vinegar, would be illegal, according to the cider vinegar standard.*

The fermentation of cider into vinegar consists of little more than a transformation of the alcohol into acetic acid under the influence of certain bacteria, notably *Mycoderma aceti* and *Bacterium Pasteurianum.* These bacteria require plenty of oxygen (air), and the fermentation proceeds best at a temperature of 65 to 75° F. The acetic bacteria possess the peculiarity of forming a gelatinous enveloping membrane, which coalescing, forms a jelly-like film, known as "mother vinegar," containing the bacteria imbedded therein. The *Bacterium xylinum* forms a particularly thick, cellulose containing "mother," and appears to be concerned in the degenerative fermentation of vinegar, by which the acetic acid is destroyed and the resulting product even rendered alkaline in reaction.

As to the details and manipulation of the "cask" method and "generator" methods of fermenting cider or "vinegar stock" into vinegar, our readers are assumed to be familiar. The "generator" process requires but a very small fraction of the time required for a "cask" fermentation and for factory purposes is the only practicable method, of course. A superior product is claimed to be obtainable by the "cask" method, supposedly due to the aromatic by-products which are formed during the year or so required to complete a fermentation of cider into vinegar when left to ferment spontaneously in a cask or barrel. We are inclined to believe, however, that much of the "bouquet" is a result of the alcoholic fermentation, and if the latter has been conducted properly a superior product is obtainable by a carefully regulated "generator" process.

The chemical equation expressing the fer-

mentation of alcohol into acetic acid is as follows:

$$C_2H_5OH + O_2 = CH_3COOH + H_2O,$$

or one molecule of alcohol, plus two atoms of oxygen, yields one molecule of acetic acid (CH_3COOH) and one molecule of water. From 100 parts (by weight) of alcohol should be obtained theoretically 130.4 parts of acetic acid. In actual practice this yield is seldom, if ever, reached, even when the alcohol lost by evaporation in an overheated generator, is allowed for. One an average 100 parts (by weight) of alcohol will furnish about 120 parts of acetic acid.

The Federal standard for apple or "cider" vinegar calls for at least 4 per cent. of acetic acid. A frequent State requirement and the customary and preferable strength for table purposes is 4.5 per cent. acetic acid. To obtain this strength it is but necessary, according to the above, that the cider contain from 3.8 to 4.0 per cent. (by weight) of alcohol, and by reference to the synopsis of alcoholic fermentation given in the preceeding article it will be seen that if a cider of that strength was submitted to acetic fermentation a large percentage of reducing sugar and a high ratio of reducing sugar to total solids would be found in the vinegar, which, according to the Federal standard, would condemn it (unjustly) as illegal. Most vinegar manufacturers allow the formation of as much alcohol as possible in the cider or "vinegar stock" of course, and the vinegar obtained by careful acetic fermentation of such will average about 6 per cent. acetic acid. To reduce this by watering to the desired 4.5 per cent. acid

strength is not only an illegal procedure, but may possibly bring the total solids, etc., below the legal minimum, especially in those States, which have not yet discovered that a requirement of 2 per cent. total solids in cider vinegar is a scientific absurdity. The alternative is to stop the alcoholic fermentation as outlined above and then be accused of having added unfermented apple material (boiled cider or apple jelly) to the product. Truly, the path of the vinegar-maker is beset with pitfalls!

Another way in which an apple vinegar may be found to have a high reducing sugar value and ratio (to total solids), without the accusation of added jelly or boiled cider being true, is as a result of the acetic fermentation getting started before the alcoholic fermentation has finished, whereby the latter is stopped, with the result that a high percentage of reducing sugars is found in the vinegar. The not infrequent practice of adding fresh apple juice to fermenting vinegar, with the false hope of hastening its fermentation into cider and later vinegar is also a cause of a high reducing sugar value. Upon distilling vinegar, the distillate is found to contain reducing substances, therefore a certain proportion of the "reducing sugars" as reported are not found in the value for "total solids," thus lowering the value for "non-sugar solids." Yet another, recently coming to the writer's attention in connection with a contemplated Federal prosecution, is the presence of a preservative in apple juice, which later may be found necessary to convert into vinegar, with the result that the complete fermentation of sugars into alocohol is prevented. Below is given a continuation of Browne's synopsis of the alcoholic and acetic

ACETIC FERMENTATION.

Date.	Specific gravity.	Total solids.	Saccharose.	d.-glucose.	Levulose.	Total sugar.	Alcohol.	Acetic acid.	Malic acid.	Ash.	Levo-rotation (400 mm. tube).
		Per cent.									
July 27	0.9959	1.80	0.00	0.00	0.11	0.11	6.86	0.52	0.20	0.26	—1.50° V
Aug. 14	0.9965	1.53	....	....	0.11	0.11	6.66	1.11	0.17	0.26	—1.20
Oct. 2	0.9988	1.48	....	....	....	....	6.01	1.77	0.16	0.26	
Nov. 27	1.0017	1.42	....	....	....	....	4.80	2.59	0.15	0.26	
Feb. 14	1.0037	1.40	....	....	....	....	4.54	3.67	0.14	0.26	
April 20	1.0060	1.37	....	....	0.18	0.18	3.77	4.31	0.14	0.26	
July 31	1.0113	1.70	....	....	0.22	0.22	2.61	5.98	0.11	0.25	—1.20
Final	1.0140	1.80	....	....	0.26	0.26	0.00	9.00	0.07	0.25	—1.20

fermentation of an apple juice, containing originally 13.36 per cent. total sugars.

Somewhat more than a year later, after a degenerative fermentation had set in, the acidity had decreased to 3.33 per cent., the total solids had increased to 2.4 per cent. (due more or less to concentration in volume of vinegar), and the reducing sugar had increased to 1.2 per cent. The acetic bacteria themselves consume the acetic acid, forming carbon dioxid and water, according to Pasteur, and the *Bacterium xylinum*, according to Bertrand,* can convert the glycerin present into dioxyacetone, which reduces a copper solution and would be reckoned as reducing sugar. Malic acid, as said previously, may disappear entirely in a fully fermented vinegar.

The Federal standard for apple or cider vinegar defines it as the "product made by the alcoholic and subsequent acetous fermentations of the juice of apples, is levo-rotatory and contains no less than 4 grams of acetic acid, not less than 1.6 grams of apple solids,† of which not more than 50 per cent. are reducing sugars and not less than 0.25 gram of apple ash in 100 cubic centimeters (20° C.), and the water soluble ash, from 100 cubic centimeters of the vinegar, contains not less than 10 milligrams of phosphoric acid (P_2O_5) and requires not less

*Comptes Rendus, 126, 842 and 984.

†The Federal inspection chemists have also been attaching considerable importance to the value for non-sugar solids, *i. e.*, the total solids minus the reducing sugars. This they claim should not be below 1.25, which, however, is not justified as occasional samples of known purity will show much less. The ratio of the ash to the non-sugar solids they claim should be between 12% and 27% (average 19%), but here also occasional pure samples will show as high as 32%, and even higher.

than 30 cubic centimeters of deci-normal acid to neutralize its alkalinity." For practical purposes "grams per 100 cubic centimeters" may be read as per cents, in vinegar, where the specific gravity is so near that of water.

The following maximum, minimum and average analytical values on pure cider vinegars (55 samples) are from the analyses by Lythgoe, A. W. Smith, Doolittle and Browne:

CIDER VINEGAR ANALYSES.

	Minimum.	Maximum.	Average.
Specific gravity	1.0126	1.0275	1.0177
Acidity (as acetic acid)	3.24%	9.96%	5.21%
Total solids	1.24	4.45	2.39
Reducing sugars	0.15	1.12	0.47
Non-sugar solids	0.85	2.89	1.90
Ash	0.20	0.57	0.38
Soluble ash	0.17	0.51	0.34
P_2O_5 in soluble ash	0.007	0.032	0.017
P_2O_5 in insoluble ash	0.004	0.031	0.012
Ratio, sugars to total solids	7.30	43.36	20.80
N/10 acid to neutralize soluble ash	21.5 c.c.	55.2 c.c.	34.2 c.c.
Levo-rotation (200 mm. tube)	—0.3° V.	—3.6° V.	—1.3° V.

A glance at the column of minimum values as compiled above will show almost every item in the analytical limits of the Federal vinegar standard to have been transgressed by apple vinegars of known purity. Only the property of levo-rotation and the very liberal 50 per cent. ratio allowed for reducing sugars in the total solids are not violated. As we have pointed out, however, there are several ways, aside from the addition of apple jelly or "boiled cider" containing much sugars, how a pure apple vinegar may contain reducing sugars in excess of 50 per cent. of the total solids.

The minimum acidity reported above is probably abnormal and may have been a deteriorated vinegar, or an underfermented one, although no unconverted alcohol was reported.

Browne gives an analysis of underfermented vinegar as follows:

Specific gravity	1.005
Total solids	1.86%
Reducing sugars	0.16
Ash	0.28
Acidity (as acetic acid)	2.60
Alcohol (by weight)	2.21

Such a vinegar, if the acetic fermentation were allowed to be completed, would be found to be up to standard as concerns acidity.

The methods of adulterating apple or cider vinegar are numerous, ranging from the crude attempt at supplying so much acid and so much solids (sometimes "ash," also, by means of mineral salts) as required in the old-time State standards and inspection departments to the latter-day shrewdly adjusted mixtures of apple jelly, boiled cider, juice from fermented apple pomace, etc., with spirit vinegar or dilute acetic acid and some straight vinegar for improving flavor and color. A little apple material added to a straight apple vinegar for the purpose of bringing naturally low solids (incidentally of no condimental value in themselves) up to some unfair state requirement of 2 per cent., although theoretically illegal, cannot be considered quite as questionable as using the apple jelly, etc., to furnish solids for dilute acid of foreign nature.

The Federal standard will easily detect the crude schemes of the past, wherein watering and adding other than apple material played prominent parts, but as concerns the shrewder practices of the present day the same cannot be said. For instance, a boiled-down juice from a long-fermented pomace contains just about the right proportion of reducing sugars to total solids, although the dextro-rotation of such a juice,

after inversion, would tend to detect its use. This juice in its original state contains only about 1 per cent. of sugars and would be of little value in vinegar fermentation. It should not be confused with a legitimate "second pressing" (made immediately after pressing for the first time) with a regulated maceration with water preceding it. Such a "second pressing" is given analytically in Part III of this series, and contains nearly as much sugars as a "first pressing." The use of such for making apple vinegar by fermentation should be allowed in the Federal standard for apple vinegar.

PART VI—WINE VINEGAR

AS pointed out in our introductory note, certain vinegars are so extensively used, or were so exclusively used originally in certain countries as to have become what may be called the national vinegar of that country. In fact, in food inspection circles it is customary to restrict the use of the single term "vinegar" to that particular "national" product, thus "vinegar" in America means cider vinegar only, and in France and Germany wine vinegar is the national" vinegar.

Just as wine itself is the oldest fermented beverage, so is wine vinegar the oldest type of vinegar. To go into the many details of manufacture involved in the production of the many varieties of wine from grape juice is beyond the scope of this article. The following analytical data on the juice of the grape is according to König and others:

GRAPE JUICE.

	Minimum.	Maximum.	Average.
Specific gravity	1.069	1.2075	1.1024
Total solids	17.90%	48.47%	25.51%
Sugars (reducing sugars).	12.89	35.45	19.71
Acidity (as tartaric acid)..	0.20	1.18	0.64
Ash (mineral matter)	0.20	0.63	0.40
Polarization (200 mm. tube)			—5.5° V.

Just as the poorer grades of apples are used for apple vinegar-making in America, so are the poorer grades of grape juice and wine used for wine vinegar-making abroad.

Disregarding the effervescent wines (champagne) and the various wines which have been "fortified" with brandy or alcohol (port, Madeira

and sherry) and in which acetic fermentation is impossble, except after dilution, we may consider the following minimum and maximum analytical figures for wines:

SIMPLE WINES (700 *Analyses.*)

	Minimum.	Maximum.	Average.
Specific gravity	0.990	1,023	0.998
Alcohol (by weight)	4.00%	12.78%	8.93%
Alcohol (by volume).....	5.00	15.70	11.00
Solids ("extract")	1.09	9.69	3.25
Sugars (reducing sugars).	0.03	6.55	0.78
Glycerol	0.46	1.09	0.59
Acidity (as tartaric acid).	0.49	1.14	0.68
Ash (mineral matter)	0.11	0.74	0.28
Potash (K_2O)	0.07	0.30	0.09
Phosphoric acid (P_2O_5).	0.02	0.05	0.03
Tannin and color	0.02	0.36	0.21*
Polarization.†	+0.6° V.	—18.6° V.	—1.50° V.

*0.04 for white wines.
†200 mm. tube.

The above maximum value for sugar represents a decidedly underfermented (sweet) wine rather than a sugared (chaptalized) product. Chaptalizing, or the addition of sugar to the original grape juice (must) for the purpose of increasing the alcohol content should not, by the way, be confused with the fraudulent practice so common in this country, known as "gallizing" or diluting the original juice with a thin sugar syrup.

The standards for grape juice and wine are as follows: "Grape juice (grape must) the fresh fruit juice obtained from grapes (Vitis species) has a specific gravity (20° C.) not less than 1.040 and not exceeding 1.124, and contains in one hundred (100) cubic centimeters (20° C.) not less than seven (7) grams nor more than twenty-eight (28) grams of total sugars in terms of reducing sugars, not less than twenty (20) centigrams and not more than fifty-five (55) centigrams of grape ash and not less than fifteen

(15) milligrams nor more than seventy (70) milligrams of phosphoric acid (P_2O_5)."

"Wine is the product made by the normal alcoholic fermentation of the juice of sound, ripe grapes and the usual cellar treatment, and contains not less than seven (7) nor more than sixteen (16) per cent. of alcohol, by volume, and in one hundred (100) cubic centimeters (20° C.), not more than one-tenth (0.1) gram of sodium chloride, nor more than two-tenths (0.2) gram of potassium sulphate, and for red wine not more than fourteen-hundredths (0.14) gram and for white not more than twelve-hundredths (0.12) gram of volatile acids produced by fermentation and calculated as acetic acid. 'Dry wine is wine in which the fermentation of the sugars is practically complete' and should contain less than one gram (per 100 cubic centimeters) of sugar, and for red wine not less than 1.6 grams and for white wine not less than 1.4 grams of sugar-free grape solids. 'Sweet wine is wine in which the alcoholic fermentation has been arrested,' and contains not less than 1 gram of sugar per 100 cubic centimeters. The ash requirements for red wines is at least 0.16 gram (per 100 c.c.), and for white at least 0.13 gram."

In the data for grape juices given above König reports a product which, on the basis of grams per 100 c.c. contained 42.5 grams of reducing sugars. This may have been a partially concentrated juice*, and the above standard limit of 28 grams per 100 c.c. for reducing sugars in fresh grape juice is probably high enough. The standards for wine, however, do not ac-

*The writer was called upon some time ago to analyze a grape juice concentrate containing 62.8 per cent. of reducing sugars.

commodate a number of high-grade white wines of known purity in which the ash has been found below the legal limit of 0.13 grams per 100 c.c. and both red and white wines in which the alcohol was considerably less than 7 per cent. (by volume). Some of the white wines below standard in ash took prizes at the Paris Exposition (see Bull. 72, Bureau of Chemistry, U. S. Department of Agriculture), and a number of these, together with some of the red wines, also contained considerably more than the legal amounts of volatile acids.

In both wine and vinegar, particularly the former, grams per 100 cubic centimeters may be read as per cents (by weight) for practical purposes. The Federal standard for wine or grape vinegar defines it as "the product made by the alcoholic and subsequent acetous fermentations of the juice of grapes, and contains in one hundred (100) cubic centimeters not less than four (4) grams of acetic acid, not less than one (1) gram of grape solids and not less than thirteen-hundredths (0.13) gram of grape ash."

It will be noticed that the standard reads "juice of grapes." We have pointed out in connection with the apple vinegar standard the absurdity of insisting upon the use of straight apple juice (meaning first pressings only) for apple vinegar-making, and in the present instance it is evident that the commission have overlooked the fact that a "second pressing," made by macerating grape pomace with water and repressing, is in common use abroad for vinegar-making. Moreover, the alcohol in the above average wine yields 10.7 per cent. acetic acid upon full fermentation, and may show as high as 15 per cent. acetic acid, either strength being en-

tirely too high for table purposes. A diluted wine or a standardized "second pressing" is necessary for table fruit vinegar-making, if dilution of finished products is to be avoided; also, if the use of selected pure cultures of wine-vinegar bacteria is to ever become practicable, it is necessary that the "vinegar stock" should not be too alcoholic. Perold (Centralblatt f. Bacteriologie, 1909) has shown that only certain powerfully acidifying bacteria found in southern European wines can live in wines high in alcohol (12 to 14 per cent. by volume), and they are apt to later consume acetic acid and give a disagreeable aroma.

Perold found but one and usually a specific variety of acetic bacteria in each kind of wine. Certain forms when isolated give a particularly fragrant vinegar, with wines of suitable strength.

The process in general use for wine vinegar-making is the Orleans process, somewhat similar to our own cask fermentation method, except that the "wine-vinegar stock" is added week by week in increasing quantities of from one-half to two and a half gallons until the original 20 gallons of vinegar is made up to about 40 gallons. Then 20 gallons of product are removed, and at the end of every following week about 2 gallons are removed and an equal volume of "vinegar stock" added. A properly prepared cask will serve for six or eight years; then it must be thoroughly cleaned of accumulated yeast, tartar and "mother vinegar."

The vinegar as first removed contains some unconverted alcohol, which, however, on ageing, is converted to acid or aids in forming esters, etc., of aromatic value. The writer has heard

of a couple of unsuccessful attempts at making wine vinegar by the generator process in this country, and he is of the opinion that, if properly conducted with not too strong an alcoholic "stock" the factory method in general use in America for apple vinegar-making can be successfully used for grape vinegar-making also.

The following data on some laboratory made white wine vinegars of known purity show the Federal standard limits to be fair, as concerns white wine vinegar. Formerly, it may be mentioned here, spirit vinegar was known as "white wine vinegar" in the United States. Much of the small amount of supposedly true white (and red) wine vinegar sold here is adulterated in various ways, so much so that the reputable wine companies have not felt encouraged to go into the regular manufacture of a product that ought to have a large sale among our European-born population.

WHITE WINE VINEGAR.

	Minimum.	Maximum.	Average.
Specific gravity	1.0129	1.0213	1.0175
Acidity (as acetic acid)	4.44%	9.38%	7.38%
Total solids	1.38	3.19	1.93
Reducing sugars	0.06	0.46	0.22
Ash (mineral matter)	0.16	0.69	0.32
Potassium bitartrate	0.07	0.36	0.17

The following is given by Weigmann as the average of a number of analyses of red wine vinegar of known purity:

RED WINE VINEGAR.

Specific gravity	1.0143
Acetic acid	7.79%
Alcohol	1.19
Glycerol	0.14
Solids	0.86
Potassium Bitartrate	0.06
Ash (mineral matter)	0.12

The above data (average values, mind you) show the Federal standard limits for "grape solids" and "grape ash" to be entirely too high

for red wine vinegars as made abroad for centuries. The further fermentation of the alcohol in the above análysis would give a total of about 9.2 per cent. acetic acid, indicating a fairly strong grade of wines to have been used, which further shows the weakness of the wine vinegar standard, at least for red wine vinegars.

Wine vinegars are usually slightly levorotatory as concerns polarization.

PART VII—MALT VINEGAR

THE most common vinegar of England, and one which is becoming well known and appreciated in America, is the product known as malt or beer vinegar. Just as the original and best beers were made from an infusion or wort extracted from malted barley, or a mixture of malted and unmalted barley, so are the best malt vinegars made entirely from malt and unmalted barley in which the starch has been changed to sugars by the action of malt.

However, as is well known, much, if not most, of the beer of nowadays is brewed from a wort derived from the mashing of not only malt and various other cereals or cereal products, but from "worts" containing glucose ("brewer's sugar"). The Federal standard for malt vinegar (Circular 19, U. S. Department of Agriculture) does not recognize the utilization of glucose in preparing a wort for conversion into malt vinegar, but provision is made for the utilization of cereals other than barley, providing the starch of the same has been converted to sugar by the action of malted barley.

In full the standard reads as follows: "Malt vinegar is the product made by the alcoholic and subsequent acetous fermentations, without distillation, of an infusion of barley malt or cereals whose starch has been converted by malt, is dextro rotatory and contains in one hundred (100) cubic centimeters not less than four (4) grams of acetic acid, not less than two (2) grams

of solids and not less than two-tenths (0.2) gram of ash, and the water soluble ash from one hundred (100) cubic centimeters of the vinegar contains not less than nine (9) milligrams of phosphoric acid (P_2O_5), and requires not less than four (4) cubic centimeters of deci-normal acid to neutralize its alkalinity."

It is unnecessary in connection with the malt vinegar standard to go into a consideration of the chemistry of and legal requirements (standard) for beer. Calculations on high-grade malt vinegars, after allowing for a loss of acetic acid in the generator equivalent to 30 per cent. of the theoretical yield, indicate the original malt infusion to have contained close to the 14.8 grams (per 100 c.c.) of solid substances in solution (about 65 per cent. of which is maltose) characterizing the so-called standard beer wort (specific gravity 1.057) of the British Inland Revenue Act. Worts intended for beer fermentation, however, although capable of being ultimately converted into malt vinegar need not be considered here, as the vinegar-yielding fermentations are conducted usually in separate establishments and with less care.

A properly prepared wort of barley malt alone will contain about 65 per cent. of the dry malt used, but malt alone is seldom, if ever, used. The best malt vinegars of England are prepared from mashing a mixture of barley malt and ungerminated barley, during which operation the enzyme diastase in the germinated barley (malt) acts upon the starch of both the germinated and unaltered barley to form the sugar maltose and a certain proportion of dextrin. Various other fermentations occur during the mashing stage, whereby soluble nitrogenous substances (pep-

tones, amides, etc.) are formed. Other cereals can be, and frequently are, substituted wholly or in part for the ungerminated barley, but the addition of fermentable sugars (glucose) to the liquid wort, or infusion resulting from mashing, should not be practised.

The alcoholic fermentation of the drawn off wort consists principally of two enzyme-caused changes: First, the conversion of the maltose* to dextrose (d-glucose), and then the conversion of the latter into alcohol and carbon dioxide by the enzyme zymase of the yeast. Both operations go on simultaneously, and from 100 parts of maltose about 51 parts by weight of alcohol is obtained theoretically. A standard malt wort would contain close to 9.1 per cent. of maltose, and according to the above statement would yield an alcoholic malt vinegar stock containing 4.64 per cent. (by weight) of alcohol. This agrees well with the alcohol of beer (English) prepared from worts of standard specific gravity.

One hundred parts by weight of alcohol yields 120 parts of acetic acid in a well-regulated generator fermentation, and the above strength alcoholic liquor thus fermented would figure out 5.57 per cent. acetic acid strength. The average acid strength of the eleven samples of pure malt vinegar reported in Allen's "Commercial Organic Analysis" was 5.5 per cent., and three well-known English brands analyzed by the writer also averaged 5.5 per cent. acetic acid.

It is probable that the use of generators in vinegar-making originated in connection with the manufacture of malt vinegars; at any rate the

* Maltose appears to be incapable of direct fermentation into alcohol.

acetic fermentation is practically always thus conducted, but at a much slower rate than in American cider vinegar-making, which enhances the value of the product. In the Hill-Evans & Co.'s establishment at Worcester, England, sometimes a month is required to complete the acidification, the liquor being repeatedly distributed by pumps over the bunches of birch twigs, by which the oxidation is effected.

Malt vinegar ranges in specific gravity from 1.013 to 1.023; therefore, for practical purposes grams per 100 cubic centimeters can be read as per cents. The proportion of solids is a little higher than in cider vinegar (but not 4 to 6 per cent., as stated by Leach), and in addition to containing considerable nitrogenous matter, as explained above, it contains phosphates and frequently unconverted maltose and dextrin.

MALT VINEGAR (14 *Samples*).

	Minimum.	Maximum.	Average.
Acidity (as acetic acid)...	2.88%	6.61%	5.50%
Total solids.*	1.68	4.28	2.75
Nitrogen	0.095	0.120	0.102
Ash.†	0.22	0.57	0.44
Total phos. acid (P_2O_5)...	0.057	0.130	0.080
P_2O_5 in soluble ash.......	0.001	0.012	.....
Decinormal acid required for soluble ash......	3.2 c.c.	24.9 c.c.	12.1 c.c.
Polarization.‡	+0.6°V.	+2.9°V.	§+1.7°V.

*Grams per 100 c.c. †Residue after burning. ‡200 mm. tube. §Three samples only.

Malt vinegar is the first vinegar that we have considered so far in which water, other than that found in fruit, is legitimately used. To make the original wort from the dry malt and other cereal products water is, of course, necessary, and as the natural mineral matter in waters from wells, etc., varies greatly in nature and quantity, it will be seen that any requirements as to the soluble ash of malt vinegar and its alkalinity, etc., are inadvisable. Thus, the use of

a water especially rich in lime salts (gypsum) would tend to reduce the natural alkalinity of the ash, due to soluble carbonates, and the phosphoric acid in the ash might be rendered entirely insoluble.

The Federal standard limits for practically everything except total ash are violated by the above data on samples of malt vinegar of known purity. A requirement of at least 90 milligrams of nitrogen to 100 c.c. vinegar would seem feasible, as the nitrogenous matter derived from the malted cereal is a characteristic and appears to vary within a comparatively small range. The dextrorotatory polariscopic reading is probably due to dextrin.

PART VIII—SPIRIT AND SUGAR VINEGARS

FROM a chemical standpoint the vinegars we are now to consider are comparatively simple as concerns their derivation, formation and composition; but with the steady increase in cost of the fruit-juice vinegars they have become very important commercial products. Spirit vinegar, for instance, is practically the only vinegar now used for pickling and the preparation of condimental compounds like prepared mustard, catsup, meat sauces, etc.

Spirit vinegar, or distilled vinegar, or grain vinegar, as it is variously called, is, as the name would imply, the product resulting from the acetic fermentation of a weak alcoholic spirit distilled supposedly from an alcoholic fermented mash of malted or otherwise prepared cereal substances, but also frequently from fermented molasses or other sugar residues. The true sugar vinegars, however, have not undergone any distillation process, but are made directly by the acetic fermentation of an alcoholic fermented solution (syrup) of sugar, or glucose, or honey.

The Federal standard for spirit or distilled vinegar specifies it as the "product made by the acetous fermentation of dilute distilled alcohol, and contains, in one hundred (100) cubic centimeters (20°C.), not less than four (4) grams of acetic acid." In spirit vinegar "grams per 100 cubic centimeters" corresponds very closely to per cent. (by weight), which multiplied by ten

gives us the customary "grain" system of acid measurement in use in trade circles. Thus 4 grams per 100 cubic centimeters is 4 per cent., or 40 "grains"; 4½ per cent. would, of course, be 45 "grains," and 10 per cent. would be 100 "grains." The usual strength at which spirit vinegar is sold by the manufacturers is 90 "grains" (9 per cent. acetic acid), the product being reduced later to the desired strength by the addition of water. For table purposes, 4 to 4.5 per cent. acetic acid is sufficient, and right here it would be interesting to know officially how criminal a proceeding this dilution of the naturally prepared 9 per cent. vinegar to a lower strength before selling at retail is considered. The dilution of a naturally prepared 6 per cent. apple vinegar to the desired 4 or 4.5 per cent. is officially frowned upon (although recently decided to be legal by the New York courts); why should not the addition of water to naturally prepared spirit vinegar be similarly regarded? The reduction of a valueless 2 per cent. of gummy matter from the apple to 1.333 per cent. "apple solids" cannot be the only explanation for the illogical exception.

The writer has tested samples of genuine spirit vinegar containing as high as 12 per cent. acetic acid, and it is probable if the acetic bacteria characteristic of the strongly alcoholic wines of southern Europe were utilized in the generators that an acid strength as high as 15 per cent. might be obtained.

The specific gravity of spirit vinegar averages about 1.01, and in addition to aldehyde there is frequently present a little unconverted alcohol. The proportion of solids is insignificant and the polariscopic reading always zero. The natural

color is a faint yellow, some samples being nearly colorless. The following maximum and minimum results may be of interest:

SPIRIT VINEGAR.

	Minimum.	Maximum.
Total solids.	0.04%	0.35%
Ash	Trace.	0.09
Acidity (as acetic).....	4.05	12.00

Spirit vinegar, in spite of its low price, is adulterated and sometimes entirely substituted by solutions of commercial acetic acid, which latter can be bought of a strength as high as 99.9 per cent. acetic acid. The concentrated acetic acid of commerce is called "glacial acetic acid." Diluted to proper strength it is sometimes more honestly sold as "imitation spirit vinegar," and owing to its close chemical similarity to spirit vinegar, perhaps even the term "artificial spirit vinegar" would be sometimes considered proper. Generally, however, the resemblance to the flavor of a good spirit vinegar is so poor as to justify only the prefix "imitation" or suffix "substitute."

The most important of the sugar vinegars is the product now being sold to considerable extent as "syrup vinegar." This results from the direct alcoholic and subsequent acetic fermentations of a sugar syrup (molasses can also be used, yielding a "molasses vinegar") of suitable strength, and if a dark-colored syrup be used (an overheated, slightly caramelized syrup, for instance) a fine color can be obtained in the vinegar resulting therefrom. Two samples recently analyzed by the writer showed about 0.25 per cent. of unchanged sucrose (also a little reducing sugar) and, as is characteristic of sucrose solutions, the direct polarization is slightly to the right (dextrorotatory) and levorotatory after inversion. The Federal standard requires at least 4 per cent. acetic acid in sugar vinegars.

The Federal standards also provide for a "glucose vinegar," the "product made by the alcoholic and subsequent acetous fermentations of solutions of starch sugar or glucose, is dextrorotatory, and contains in one hundred (100) cubic centimeters (20° C.), not less than four (4) grams of acetic acid." This vinegar frequently smells and tastes of fermented starch. The small proportion of solid matter consists of unchanged glucose, particularly the dextrin portion, and like glucose solutions generally, it is strongly dextrorotatory as concerns polarized light, both before and after inversion. The ash is mainly lime salts present in the glucose as a result of the process of manufacture.

In the southwest several successful attempts have been made at making a vinegar from a solution of honey. Owing to a deficiency in nutrients, particularly nitrogen, potassium and phosphoric acid, for the yeast plant, it has been found advisable to add to the dilute honey solution a small proportion of certain chemical salts which, in conjunction with yeast cake, has been found to promote a rapid alcoholic fermentation. Several acceptable formulæ are available. The honey "wine" is then racked off, mixed with some good vinegar, or inoculated properly with "mother vinegar," and after an acetic fermentation of from four to six months at proper temperatures, a very good honey vinegar is obtained.

Vinegars can also be made from other fruit juices than apple and grape. A very good vinegar has been made in the Northwest from prunes, and experiments at making a pineapple juice vinegar are now under way at the factory of a client of the writer's. Probably the generator process could be used in the manufacture of honey vine-

gar, thereby effecting a great saving of time, and also probably in the manufacture of pineapple and other new fruit juice vinegars.* There is plenty of room in trade circles for both the old and new vinegars, particularly vinegars of quality, which of late years have become difficult to find.

*A Bureau of Chemistry circular (No. 51), just issued, reports on the successful manufacture of a peach juice vinegar, using a small generator.

PART IX—TOMATO CATSUP

AT the present moment the manufacture and trade in tomato catsup is in the midst of an industrial revolution. The shortsightedness and cupidity of the canners and the undesirable conditions brought upon the manufacturers of catsup by the same are now bearing fruit. New standards of judgment are being utilized by inspection officials, which sometimes wrongly, but often rightly, condemn grades of catsup that might never have needed condemnation but for the gross carelessness and filthiness of the canners who have been supplying the tomato pulp.

There is no reason why a given batch of tomatoes should not furnish both the canned product and a very satisfactory pulp for the cheaper grades of catsup. Both the farmer and the canner, however, have trained themselves to believe that any old sort of tomato leavings was all right for catsup-making, and the result is that what might have been from the first a clean, legitimate product has become so abused and commercially adjusted and fixed in its dirtiness that the sale of the same is already greatly curtailed and may be officially interdicted.

The sliced-off tops and the pulp adhering to the skins, which under the name of "tomato trimmings" are rejected in the preparation of canned tomatoes can be so handled (and the illegitimate habit of adding the rotten and moldy

tomatoes could have been avoided), that a catsup pulp, analyzing much the same as the whole tomato and unobjectionable from a sanitary standpoint would have resulted, well suited for cheap catsups. Instead, however, the product has been so generally found to be thickly infested with molds, yeasts, excess of bacteria, etc., as a result of dirty canning factory methods, that the presence of such organisms, even when killed by the cooking, and perhaps coming from an innocent fermentation in the storage barrel or a fermenting process such as sometimes used in catsup making, is being regarded as proof (?) that the raw material was "filthy, decomposed vegetable matter."

Right here let us say that the benzoate preservative that allows of a tomato flavor in tomato catsup (instead of strong spices, acetic acid and excess of sugar otherwise necessary) should not be held responsible for filthy canning factory methods. Cooking and hermetical sealing will preserve stuff that the legal proportion of benzoate cannot save, and the filthiest tomato paste the writer was ever called upon to analyze was effectually preserved by such an honorable method.

As said above, the presence of molds, yeasts, etc., are being utilized by food inspection officials as evidence that the catsup pulp was made from dirty "trimmings," notwithstanding that all the organisms have been killed by the cooking. If a clean pulp of this nature is not now practicable it would be well to interdict the sale of such. This should be done, however, by chemical methods and not by microscopical conclusions, as it can be demonstrated that molds, yeasts, etc., can be just as plentiful in whole tomato catsup pulp as in the above abused product and may

come from innocent fermentations constituting an old legitimate catsup-making process.

Only recently have we had enough chemical data on catsups and different parts of the tomato to enable reliable judgments as to the use of an excess of "trimmings," and although the first interpretations of this data were faulty and the standards proposed unfair, the chemical data itself is very valuable and a credit to the Connecticut State Experiment Station, where most of it was determined (see Annual Report for 1910).

The principal reason for the faulty conclusions drawn and unfair standard proposed was that, although the added salt in a catsup was allowed for, no allowance was made for the sugar added by manufacturers in widely different proportions; so that if one maker was selling what is being nicknamed a "tomato syrup," containing 25 per cent. sugar, and another was selling more tomato and only a very little sugar, the former's product would comply with the standard proposed, while the latter's would not!

Being able to check up the data on different parts of the tomato so as to get on a dry sugar-free basis and refer back the other analytical items to this basis, the writer has recalculated the Connecticut Experiment Station catsup analyses (seventy-four in all) to a dry, salt and sugar-free basis with results which appear promising of both a method of detecting excess of skin pulp ("trimmings") and of a logical, fair standard for whole tomato catsup. Although, of course, the seeds are always strained out, the Connecticut Station data on them is given below for completeness. Also it should be remembered that the fibrous pieces of true skin are mainly kept out of the catsup. Skin was found to con-

stitute about 10 per cent. of the tomato and seeds about 5 per cent.:

TOMATOES.

	Per cent.			
	Whole fruit.	Pulp.	Skins.	Seeds.
Total solids	4.37	3.62	6.46	12.55
Insoluble solids	1.44	0.64	3.62	10.30
Soluble solids	2.93	2.98	2.84	2.25
Sugars	2.37	2.25	3.15	2.91
Sugar-free solids	2.00	1.37	3.31	9.64
Crude fiber	0.46	0.22	1.75	1.93
Ash	0.42	0.41	0.48	0.44
Fatty oil	0.27	0.09	0.11	3.38
"Protein"	0.85	0.65	0.97	3.89

The above data, calculated to a dry basis, gives the following results and ratios:

TOMATOES (*Water-free Basis.*)

	Per cent.			
	Whole fruit.	Pulp.	Skins.	Seeds.
Insoluble solids	32.95	17,68	56.04	82.07
Soluble solids	67.05	82.32	43.96	17.93
Sugars	54.23	62.14	48.76	23.18
Sugar-free solids	45.77	37.86	51.24	76.82
Crude fiber	10.53	6.08	27.09	15.38
Ash	9.61	11.33	7.43	3.51
Fatty oil	6.18	2,49	1.70	26.93
"Protein"	19.45	17.96	15.02	31.00
Insol. solids in sugar-free solids	71.9	46.7	109.3	.....
Fiber in sugar-free solids	23.0	16.0	52.9	.....
Ash in sugar-free solids	20.9	29.9	14.5	.....

The data of most interest in the above calculation of tomato constituents to a dry basis are the last three ratios, for by calculating the tomato catsup to a similar dry, salt and sugar-free basis it will be seen that catsups of known purity have very similar ratios to those given above for tomato pulp. The above three ratios for the whole fruit are, of course, rendered useless by the inclusion of the seeds, while as concerns skins, one cannot expect to find the ratio of fiber to sugar-free solids duplicated in so-called "core and skin" ("trimmings") pulp catsups, because the fibrous true skin is also largely kept out of catsup. The following recalculated analyses of

ten catsups, known to be whole pulp goods, and five known or judged to be made mainly from "trimmings," show particularly the value of the ratio between insoluble solids and the sugar and salt-free solids. The reversal of the ratio of salt-free ash to sugar and salt-free solids the writer attributes to the dirtiness of "trimmings" as often sold.

As at present defined in the Federal food standards (Circular 19 of the Office of the Secretary of Agriculture), "Catsup (ketchup or catchup) is the clean, sound product made from the properly prepared pulp of clean, sound, fresh, ripe tomatoes, with spices and with or without sugar and vinegar." No analytical limits are fixed to determine if whole pulp, for instance, has been used, nor is there any restriction against the use of clean "trimmings," but if the latter product is non-existent, as claimed by some manufacturers, and now impracticable to make and sell, it may be advisable to insist that catsup be made from whole tomato pulp only. The above data suggests the following standard limits for such a catsup, viz.: Insoluble solids not less than thirty (30) per cent. nor more than sixty (60) per cent. of the sugar-free, salt-free solids; crude fiber not more than sixteen (16) per cent. of sugar-free, salt-free solids; salt-free ash not more than thirty (30) per cent. of sugar-free, salt-free solids; sugar-free, salt-free solids not less than four (4) per cent.

The last requirement would cause the rejection of two of the catsups of known purity, but as one sells for a very high rate per pound, the manufacturer can afford to sell a little more tomato, with less sugar if necessary. This brand, by the way, is just on the border-line of the above proposed standard throughout.

CATSUPS OF KNOWN PURITY.

Brands.	Cost, per lb.	Total solids.	Sugar-salt-free solids.	Insoluble solids.	Crude fiber.	Salt-free ash.	Salt.	Total ash.	Sucrose.	Invert sugar	Total sugar.	Protein.	Acetic acid.	Undetermined.	In sugar-salt-free solids. Insol. solids	Fiber.	Salt-free ash.
B.	23.6	18.51	2.74	1.65	0.39	0.88	1.57	2.40	3.63	10.57	14.20	1.56	1.20	0.04	60.2	14.2	30.8
Hz.	25.7	32.49	4.62	2.09	0.42	0.93	3.05	3.98	7.34	17.48	24.82	2.13	1.98	1.14	45.3	9.1	20.1
Hd.	10.3	15.95	2.91	1.63	0.35	0.77	3.00	3.77	0.97	9.07	10.04	1.44	1.20	0.35	56.0	12.0	26.4
C.	19.6	15.16	4.18	2.06	0.48	0.79	2.47	3.26	0.00	8.51	8.51	1.69	0.85	1.22	49.3	11.5	18.9
P. F.	13.5	12.76	5.07	2.86	0.54	0.69	1.67	2.36	0.03	5.99	6.02	1.75	1.29	2.09	56.4	10.6	13.6
S.	17.4	18.78	4.69	2.10	0.35	0.83	3.39	4.22	2.35	8.35	10.70	1.56	0.90	1.95	44.8	7.5	17.7
O. V.	14.6	18.65	5.97	2.95	0.69	1.60	2.71	4.31	4.62	5.35	9.97	1.63	1.68	2.05	49.4	11.5	26.8
Sb.	17.3	22.18	5.38	2.36	0.36	1.78	2.42	4.20	4.26	10.17	14.43	2.44	1.05	0.75	44.3	6.8	33.4
C. C.	15.3	18.47	4.14	2.21	0.39	0.96	2.95	3.91	2.97	8.41	11.38	1.63	1.14	1.16	53.4	9.4	23.2
V. C.	13.3	20.10	5.33	3.32	0.51	1.22	2.56	3.78	1.48	10.73	12.21	2.50	1.44	1.10	62.3	9.5	22.9
Average	...	.....	4.50	2.32	0.45	1.04	....	....	....	.....	.....	....	....	....	52.1	10.2	23.3

CATSUPS FROM "TRIMMINGS."

Brands.	Cost, per lb.	Total solids.	Sugar-salt-free solids.	Insoluble solids.	Crude fiber.	Salt-free ash.	Salt.	Total ash.	Sucrose.	Invert sugar	Total sugar.	Protein.	Acetic acid.	Undetermined.	In sugar-salt-free solids. Insol. solids	Fiber.	Salt-free ash.
S. C.	9.9	14.66	2.24	1.96	0.48	0.68	1.86	2.54	4.31	6.25	10.56	1.18	0.72	0.05	87.5	21.4	30.4
R.	23.5	15.57	2.62	1.95	0.44	1.20	1.63	2.83	4.18	7.14	11.32	1.50	0.78	0.52	74.4	16.3	46.0
O.	11.8	24.74	3.04	2.28	0.32	1.59	3.00	4.59	6.17	12.53	18.70	2.38	1.14	1.25	75.0	10.5	52.3
I. D.	14.5	12.97	3.45	2.45	0.43	0.82	0.95	1.77	3.52	5.05	8.57	1.00	0.93	1.20	71.0	12.5	28.7
M.	23.1	18.56	3.18	2.28	0.39	1.47	2.15	3.62	4.07	9.16	13.23	2.13	1.14	0.84	71.7	12.2	46.2
Average	...	.....	2.91	2.18	0.41	1.15	....	....	....	.....	.....	....	....	....	75.9	14.7	39.7

APPENDIX

Office of the Secretary
United States Department of Agriculture.

FOOD INSPECTION DECISION 140.

(Issued Feb. 27, 1912.)

Labeling of Vinegars.

The Board of Food and Drug Inspection has given this question much consideration. A public hearing was given, a series of questions submitted to the various State food commissioners, interested manufacturers, wholesalers, retailers and consumers, and a study of the various State laws and regulations was made, believing that these represent the general understanding of the terms by the people of those States. From the information thus obtained the board has reached the conclusion that the definitions given in Circular No. 19, Office of the Secretary, are in accordance with the facts. These are as follows:

1. *Vinegar, cider vinegar, apple vinegar,* is the product made from the alcoholic and subsequent acetous fermentations of the expressed juice of apples.

2. *Wine vinegar, grape vinegar,* is the product made by the alcoholic and subsequent acetous fermentations of the juice of grapes.

3. *Malt vinegar* is the product made by the alcoholic and subsequent acetous fermentations, without distillation, of an infusion of barley malt or cereals whose starch has been converted by malt.

4. *Sugar vinegar* is the product made by the alcoholic and subsequent acetous fermentations of solutions of sugar, sirup, molasses; or refiner's sirup.

5. *Glucose vinegar* is the product made by the alcoholic and subsequent acetous fermentations of solutions of starch sugar or glucose.

6. *Spirit vinegar, distilled vinegar, grain vinegar,* is the product made by the acetous fermentation of dilute distilled alcohol.

Several questions regarding these definitions have been raised and after investigation the board has reached the following conclusions:

Meaning of the term "vinegar."—While the term "vine-

gar" in its etymological significance suggests only sour wine, it has come to have a broader significance in English-speaking countries. In the United States it has lost entirely its original meaning and when used without a qualifying word designates only the product secured by the alcoholic and subsequent acetous fermentation of apple juice.

"Second pressings."—It is held that the number of pressings used in preparing the juice is immaterial so long as the pomace is fresh and not decomposed. The practice of allowing the pomace from the presses to stand in piles or in vats for a number of days, during which time it becomes heated and decomposed, and then pressing, securing what is ordinarily called "second pressing," in the opinion of the board produces a product which consists in whole or in part of a filthy and decomposed material and is therefore adulterated.

Vinegar from dried-apple products.—The product made from dried-apple skins, cores, and chops, by the process of soaking, with subsequent alcoholic and acetous fermentations of the solution thus obtained, is not entitled to be called vinegar without further designation, but must be plainly marked to show the material from which it is produced. The dried stock from which this product is prepared must be clean and made from sound material.

Addition of water.—When natural vinegars made from cider, wine, or the juice of other fruits, are diluted with water, the label must plainly indicate this fact; as, for example, "diluted to — per cent. acid strength." When water is added to pomace in the process of manufacture, the fact that the product is diluted must be plainly shown on the label in a similar manner. Dilution of vinegar naturally reduces, not only the acid strength, but the amount of other ingredients in proportion to the dilution, so that reduced vinegars will not comply with the analytical constants for undiluted products; but the relations existing between these various ingredients will remain the same. Diluted vinegars must have an acid strength of at least 4 grams acetic acid per 100 cubic centimeters.

Mixtures of vinegars.—As different kinds of vinegar differ in source, flavor and chemical composition, mixtures thereof are compounds within the meaning of the Food and Drugs Act, and if they contain no added poisonous or other added deleterious ingredients will not be held to be misbranded if plainly labeled with the word

"compound," together with the names and proportions of the various ingredients.

Addition of boiled cider and coloring matter.—The Food and Drugs Act provides that a product shall be deemed to be adulterated if it be mixed, colored, powdered, coated, or stained in a manner whereby damage or inferiority is concealed; and, in the opinion of the board, the addition of coloring matters, boiled cider, etc., to vinegar, wine vinegar, and the other types of vinegar, or mixtures thereof, is for the purpose of concealing damage or inferiority or producing an imitation product. In the first instance, the use of such products is an adulteration and therefore prohibited. Products artificially colored or flavored with harmless ingredients in imitation of some particular kind of vinegar will not be held to be misbranded if plainly labeled "imitation vinegar" in accordance with the provisions of the law.

Mixture of distilled and sugar vinegars.—The product prepared by submitting to acetous fermentation a mixture of dilute alcohol (obtained, for example, from molasses by alcoholic fermentation and subsequent distillation) and dilute molasses, which has undergone alcoholic fermentation, is not "molasses vinegar" but a compound of distilled vinegar and molasses vinegar; such mixtures, however, must contain a substantial amount of molasses vinegar and not a small amount for the purpose of coloring the distilled vinegar. The molasses used must be fit for food purposes and free from any added deleterious substances.

Acetic acid diluted.—The product made by diluting acetic acid is not vinegar and when intended for food purposes must be free from harmful impurities and sold under its own name.

Product obtained by distilling wood.—The impure product made by the destructive distillation of wood, known as "pyroligneous acid," is not vinegar nor suitable for food purposes.

Acid strength.—All of the products described above should contain not less than four (4) grams of acetic acid per one hundred (100) cubic centimeters.

H. W. WILEY,
R. E DOOLITTLE,
Board of Food and Drug Inspection.

Approved: JAMES WILSON,
Secretary of Agriculture.

Washington, D. C., Feb. 12, 1912.

REMARKS

It will be seen that the vinegar definitions as given and interpreted in the preceding pages remain unchanged in the above labeling decision. The analytical limits as given in the Federal (Circular No. 19) standards are official (having the sanction of Congress, which the above decision has not), but in actual inspection practice are being supplemented by a number of new items which, it has been ruled by courts, can be properly utilized in the legal judgment of vinegars. Thus in cider vinegar, in addition to non-sugar solids and ratio of the ash to the same, are being considered the lead number and percentages of glycerin and pentosans. A considerable number of generator cider vinegars have been found to contain from 0.24 to 0.45 per cent. glycerin, and a couple of cases have been prosecuted and won on account of a low glycerin value. It has been shown that the pentosans in cider vinegar rarely exceed 0.18 per cent., higher figures suggesting use of apple waste (cores and skins). Both of these new items of judgment require substantiation as concerns occasional natural exceptions. In malt vinegar it has been shown by the writer (and by Chapman in England) that a natural legitimate levorotatory polarization can occur, due to the cereal proteids not having been as completely decomposed during the fermentations as is usual.

In general the legal purity analysis of vinegars has become a very delicate and intricate proposition, requiring much technique and all possible experience.